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Making mobile learning work:

case studies of practice

Editors John Traxler, University of Wolverhampton

and Jocelyn Wishart, University of Bristol

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DISCUSSIONS IN EDUCATION SERIES

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Introduction

John Traxler, University of Wolverhampton

Who is this written for?

This publication has been written and edited for the education community in UK higher education. It highlights a small number of the significant 'mobile learning' projects currently underway in the UK and tries to draw out their significance specifically for the education community. This introduction provides a working definition of mobile learning and then tries to identify the meaning and the limitations of the projects described specifically for a readership working in education.

What is mobile learning?

After extended discussions within the mobile learning research community about the definition, it is probably just 'learning with mobile devices'. Why all the discussion? Perhaps in the early days 'learning with mobile devices' just seemed too simple. There were however other factors too. In those early days, it quickly became apparent that mobile learning represented something much more significant than just the chance to access old-style e-learning whilst on the move, or just to open up old-style e-learning to new communities and indeed new countries. It could certainly do these things, and many early projects had these kinds of aims. It could also offer something new and unique, the chance to extend the ideas of learning in ways that actually delivered on earlier promises and aspirations for learning specific to each and every learner whatever they were doing, who they are and where they were.

'Mobile devices' include smart-phones, games consoles, media players, netbooks and handheld computers. Perhaps the various functions - and the mobility - are more important than the individual marketing niches or social groups associated with each category of devices. These functions include connecting and communicating via telephone network, wireless network and Bluetooth connection; capturing and storing data that might be voice, location, position, change in position, inclination, image, video, text or number; running applications comparable to computer programs; and providing output in the form of documents, movies, music and animations.

By now almost everyone owns one and uses one, often more than one. Not only do they own them and use them but they also invest considerable time, effort and resource choosing them, buying them, customising them and exploiting them. These handheld devices express part or much of their owners' values, affiliations, identity and individuality through their choice and through their use. They are both pervasive and ubiquitous, both conspicuous and unobtrusive, both noteworthy and taken-for-granted in the lives of most people. This explains in part why mobile learning is not just e-learning on mobile devices; it also hints that we might leverage learners' own devices and in doing so take education into new modes, spaces and places.

If we look at these mobile devices and technologies, especially if we make a comparison with desktop PC devices and technologies, what we see is diversity, transience and incoherence. This is potentially challenging for teachers and lecturers who are used to the stability and apparent permanence of the PC format. Mobile devices come in all sorts of shapes and sizes, with all sorts of keyboards (some virtual, some real) and screens; running various operating systems, applications, networks and connectivity, any of which will change overnight, even those as supposedly stable and standard as Java Mobile Edition. There is no standard footprint or format. They can be any size from slim matchbox to sturdy paperback book; landscape or portrait. They may open out, slide open or not open at all; have a real keyboard, a virtual keyboard or instead may respond to voice, touch, gesture or stylus; they capture or play various media and connect to various networks and devices. New mobile technologies are continually coming to maturity and perhaps coming to market. These include flexible screens, virtual keyboards, full internet access, pico (that is, smaller than microscopic) technologies, mobile social software, location-awareness, haptic interfaces, wearable devices, voice-activation, multi-player gaming and mobile TV, and behind them; enhanced forms of service, connectivity and data. The issue is, however, how technology is packaged, presented and marketed. Given current trends, it seems inevitable if there is a business case for these or any other features, they will be marketed around mobile phones, though more features will also go into media players and into games consoles. Of course, many projects, especially research projects and early projects, sought to avoid this diversity, transience and confusion by providing learners each with a standard device and given adequate finance this might still be a possible scenario for wide-scale sustainable deployment. If however we are looking for scalable, sustainable mobile learning in all the various sectors and communities we must at least think seriously about learners' own devices as the delivery mechanism.

Where did mobile learning come from?

Mobile learning in the UK and, more broadly, in much of Europe and North America largely grew out of their respective communities of e-learning , each with its associated expectations, ambitions and frustrations together with its respective methods and technologies, adopted and adapted. This meant that many early mobile learning projects tried merely to port e-learning methods or techniques, the virtual learning environment (VLE) for example, onto specific mobile platforms. This quickly exposed the obvious limitations of the mobile phones and the PDAs (personal digital assistants) of the time, the early 2000s, compared to computers, for instance, connectivity, functionality, battery life, screen size and processor speed, whilst failing to exploit the unique opportunities.

At this time, mobile learning researchers and other researchers in technology-enhanced learning were working in environments where, owing to the small number of powerful devices amongst the wider public, they could define the agenda and set the pace, and where their work took place within or from institutional settings. One of the most significant changes between then and now has been the extent to which these wider publics own, understand and control increasingly more powerful personal devices, an historic change from the earlier eras when institutions own, managed and controlled the technologies of education. Now the wider publics have their own ideas about learning with mobile devices and set the pace with which researchers and educators must keep up.

Also in these early days, the platforms were diverse and difficult to work with, very different from desktop computers where GUI, Wimp, QWERTY and HTML had been a stable foundation for e-learning for a decade or more. Much early effort was diverted into just getting expensive and unusual mobile technology to connect and function, but now consumer pressure from the wider public ensures increased and comparatively reliable functionality and performance are far more readily available for mobile learning.

Many of the case studies presented later in this publication take place in a very different environment. However, in order to provide some background for these case studies, it is worthwhile looking back at the achievements of the mobile learning community.

Where is mobile learning making a difference?

In these past ten years or so, the mobile learning community has demonstrated that it can enhance, extend and enrich the concept and activity of learning itself. This has happened in a number of different ways. The first is the possibility of contingent mobile learning and teaching, where learners can react and respond to their environment and their changing experiences, where learning and teaching opportunities are no longer pre-determined beforehand. Learners may, for example, gather and process fieldwork data in situ in real-time on geography field trips and then instantly follow up with further investigations based on their own findings, hunches or curiosity. Previously they would have retreated indoors to transcribe measurements and perform calculations before going back out. Likewise, teachers can now change and improvise their teaching in response to the changing nature of the environment and their learners, for example using pico-projectors and improvised interactive whiteboards in the field or using personal response systems with groups of learners to assess progress and comprehension in the lecture, changing the pace, emphasis or direction of lessons and lectures on-the-fly. The second is situated learning, where learning takes place in surroundings that make learning meaningful, for example learning religious studies whilst visiting temples, mosques, churches and synagogues, learning about fish biodiversity whilst at sea or learning a foreign language in the appropriate foreign community. The third is authentic learning, where learning tasks are meaningfully related to immediate learning goals, for example doing drug calculations on hospital wards. In fact, situated learning and authentic learning should both be intrinsic parts of any course and programme with fieldwork activities, such as environmental sciences, urban planning, biology, geology, heritage studies and geography. They should also be intrinsic parts of any vocational or professional course with a major element of work experience, such as training to be a teacher, nurse, doctor or vet, where long periods are spent away from university or college getting practical experience with established practitioners and professionals. For these placements, mobile learning has allowed trainees to stay in touch with tutors and fellow trainees; to access reference material and course material; and to work on assessments, capture

reflections, make observations and keep logs. The fourth major but related achievement is context-aware learning, where learning is informed by the history, surroundings and environment of the learner, for example learning in art galleries, botanical gardens, museums or heritage sites. Context-aware mobile learning means that learners at a specific location or venue, for example standing in front of a painting or tree, can automatically access progressively more background material in the form of audio, video, quizzes and interactions to enrich their understanding and experience of the place or event. A fifth major achievement has been in the area of personalised learning, where learning is customised for the interests, preferences and abilities of individual learners or groups of learners.

Other areas where mobile learning is enriching the learner experience include location-specific student support systems such as the open source Mobile Oxford and My Mobile Bristol applications. These systems enable students at Oxford and Bristol universities to find any information they need. They can find, for example, which bus to take them to the library holding the book they want at a particular moment in time, even allowing for multiple buses and multiple copies of the book being lent and returned at different libraries.

Game-based learning is now increasingly mobile and assessments and tests are now increasingly exploiting the affordances of mobile technologies, for example with physiotherapy students capturing visual proof of treatments in situ and trainee motor vehicle mechanics capturing evidence of their competence at engine maintenance procedures. In addition, e-portfolio systems such as Pebble Pad are migrating onto mobile phones allowing reflection on learning to be captured straightaway.

These achievements have usually been focused on pedagogy and technology, and have often been part of the research work of universities and institutes, separate from mainstream teaching and learning. Consequently, most of this research and development has been proof-of-concept, project-based, fixed-term and small-scale with little consideration of how to embed, sustain or scale up.

Sometimes these achievements have been technology-driven, in the sense that specific technological innovations, such as the iPhone, have been deployed in academic settings to demonstrate technical feasibility and pedagogic possibility. Sometimes, especially in the early days, they have been miniature but portable e-learning where mobile technologies have been used to re-enact approaches and solutions found in conventional e-learning, porting some e-learning technology such as a VLE onto mobile technologies, an understandable and cautious approach that allows existing e-learning players to extend their expertise and content incrementally. Sometimes they have used mobile technologies inside classrooms to support collaborative learning on a more personalised basis.

The mobile learning community has however also demonstrated that it can take learning to individuals, communities and countries that were previously too remote or sparse, economically, socially or geographically, for other external educational initiatives to reach. This has taken a variety of forms.

Firstly, it has addressed geographical or spatial distance, for example reaching into deeply rural areas. This option is becoming educationally richer as networks drive out greater bandwidth and coverage but is however still sometimes held back by shortage of more modern handsets and support, and perhaps by tariffs. It is related to addressing the challenge of sparsity, connecting thinly spread learners together to create viable communities of learners, sometimes held back by lack of experience in supporting communities of distance learners and sometimes by the ways that the most widespread network tariffs restrict access to services. Mobile learning has also addressed the most obvious infrastructural or technical barriers in, for example, areas of South Asia or sub-Saharan Africa, supporting those communities lacking mains electricity, secure clean buildings and landline connectivity. Mobile learning has been used to address different challenges of distance, sparsity and separation in Britain and now elsewhere in Europe, those of social exclusion where the distance and separation are economic or social. It has enabled educators to reach students unfamiliar with and lacking confidence in formal learning, for example the homeless, travellers, marginal groups, those not-in-education-employment-or-training (NEETs), non-traditional students, those with no tradition of education in their families, streets, neighbourhoods or communities.

Physiological or cognitive differences are another area where mobile learning has reached across a divide. Providing better learning opportunities for people with dyslexia or impaired hearing is also bridging forms of distance and separation. Many mobile learning initiatives now show how these individuals and communities can be supported and enabled within mainstream education. Another distance or separation from mainstream education can be that experienced by those closely chaperoned girls or women from some traditional communities that only allow them very constrained or circumscribed access to informal learning and social learning. Mobile learning connects these learners back into the community of their peers and enables private learning.

Another aspect of the ability of mobile learning to provide extra opportunities for learning is the way mobile devices can be used in *dead-time,* small bursts of otherwise unused time, such as waiting in lifts, cafes, buses or queues. This is also significant as an example of bite-sized learning. Although possibly educationally limited and perhaps even educationally trivial, mobile phones will always be carried by learners whereas books or laptops might not be. Work-based learning and mobile training are specific

applications of mobile learning, based on the capacity to deliver authentic and situated learning and on the capacity to deliver learning to so many more diverse and challenging work environments. They have been used with a range of jobs and sectors from truck drivers and railway workers to fast food staff, armed forces personnel and regional sales staff.

Challenges to the creation of mobile learning opportunities

Mobile learning, or perhaps 'learning with mobile devices', should be obvious, it should be a *no-brainer*, it ought to be easy and it ought to be successful. Most people have mobile connected devices, most people want to learn or have to learn so what could be easier? There are however still misconceptions, mistakes and challenges.

The first of these are based on misconceptions about how easy it will be to scale-up, sustain and embed our mobile learning trials and projects. The community must develop a much better understanding of how specific pilots, projects and trials can be safely enlarged, how test sites and samples can be best deployed and extrapolated and learn how to disentangle some outcomes that have been contingent on specific and possibly insignificant local factors. The community needs to understand how to abstract or generalise; it also needs to think about transferability and relevance and to develop an understanding of how the lessons, mechanics or principles of projects, pilots and trials can be applied elsewhere with confidence. Sustainability is a related misconception. The community, especially the corporates and private sector organisations, must develop an understanding of mobile learning projects in terms of their ability to generate revenue or meet their costs and an understanding of their impact on human, economic and social capital in relation to their various costs. The concept of embedding is part of the same set of misconceptions. It means the integration with other technology enhanced learning systems, such as virtual learning environments, and with institutional and organisational processes. The misconception is that it will be easy, a foregone conclusion. It has however proved difficult owing to funders, researchers and developers prioritising the project rather than the environment of the host institution or system, of perhaps cultural and psychological differences between innovators, especially outsiders, and regulators and administrators.

The last but related misconception surrounds the nature of evidence derived from mobile learning trials and pilots. The community needs evidence that demonstrates relevance, significance and impact. Mobile learning researchers and developers have not always had the time, resources and expertise to generate credible and appropriate evidence. The evaluation of mobile learning has been inherently challenging compared to e-learning because the context and the environment act as confounding variables, attenuating the signal-to-noise ratio; because the 'Hawthorne effect' comes into play;

because the evaluations focus inappropriately on *hard* objective outcomes and because short-term projects do not give time for the technology to bed in reliably and for the novelty to wear off. Furthermore because projects, for ease of experimental design and deployment, invariably used project devices not learner devices, outcomes even if good educationally are still nevertheless unsustainable for financial reasons. Projects are also likely to work with enthusiastic innovative teaching staff alongside, not within, compulsory curricula thus undermining the credibility or transferability of some outcomes to the core curriculum with mainstream teachers.

Learning from case studies

Given the increasing popularity of mobile learning we must acknowledge that there several other sources and sets of case study material, some now relatively old (Kukulska-Hulme and Traxler, 2005; JISC, 2005) and some more recent (JISC, 2010). There is now at least nine years' worth of research output that has been presented at the annual MLearn and IADIS Mobile Learning conferences and contains accounts of a wide range of projects. The current set of case studies presented here represents an attempt to draw a handful of relatively recent and innovative projects from this research literature into a more accessible format in the context of contemporary concerns. The selection criteria and the subsequent editing were designed with this in mind.

It is worth thinking about what one reads or does not read in any of these case studies and in any sets of case studies, especially those deliberately assembled with some illustrative purpose. Case studies continue to be a popular method of influencing both policy and practice and some skill and perhaps scepticism in reading them is valuable.

Firstly, we almost never read about failure. Failed projects do not get selected or probably even published, whilst most published projects are at least presented as 'partial successes'. This actually represents missed opportunities; greater visibility and scrutiny for what funders or researchers see as 'failed' projects would be very instructive and would open up far greater understanding of the mechanics of projects and pilots. A factor at work is the corporate prestige and momentum of both the project host and the project funder which means that projects can be effectively 'doomed to succeed' and analytic, balanced and nuanced accounts are rendered inappropriate. The official appetite for 'evidence-based policy formulation' has been derided as 'policy-based evidence formulation'. The need for funders to fund 'successes' is part of the processes that lead to this cynicism. The reluctance and sometimes lack of expertise of funders to push deeper than fairly sweeping upbeat outcomes and unpack details reinforces this. Amongst the mobile learning research community, the focus on technological innovation and pedagogic intervention has sometimes been at the expense of expertise, resources, objectivity and imagination in the evaluation of projects.

Furthermore, either explicitly or implicitly, the reader of one or more case studies is being asked to make inferences about whether it is possible to abstract, generalise or transfer from what they have read into a new environment. They are however attempting to do this on a handful of instances with a very partial account of the background. Accounts of projects and especially evaluations of projects are obviously skewed towards the kinds of backgrounds, understandings and perspectives that authors bring with them as they attempt to understand and explain, and the reader does something similar in the inferences and generalisations they make about what they read.

Introducing the case studies featured in this publication

In the following case studies of mobile learning projects in UK Higher Education settings and secondary schools the authors were asked to address the pedagogy underpinning their use of mobile devices as well as the technology itself. Also, with the aim that this publication should be of direct relevance to practitioners considering how involve students' mobile devices in supporting their learning, authors were asked to include:

- any organisational or logistical issues they found;
- the acceptance and/or attitudes of their students and
- any sustainability, scalability or other issues noted.

The contribution by the team from the Schools of Education and Geosciences at Aberdeen (page 13) sees texting (Short Messaging Service or SMS) being taken beyond organisational and pastoral support for students, and beyond bite-sized content delivery and short quizzes to now being used, perhaps for the first time, for an innovative pedagogic format uniquely suited to the technology. This is clearly a sustainable and scalable pedagogy, one that would work across a range of environments.

The contribution from Nicola Beddall-Hill (page 18), a doctoral student at City University, London describes working with groups of postgraduate students to exploit the capacity of mobile devices to enhance and enrich field-trip activities. It explores and analyses the pedagogy of field-trips as the prelude to discussing technology. As with other contributions however, the evolving debate about the use of personal learner-owned devices vs the use of institutionally-provided devices intrudes and more of the factors and issues are laid out. Like most of the contributions, this one is developmental and illustrates how mobile learning research and mobile learning pedagogy are intimately related, both pushing the continued development of new thinking, techniques and approaches. It also illustrates the facts that mobile technologies transform both social interactions and pedagogic interactions leading to the observation that mobile learning is seldom likely to be merely the same learning as before delivered differently.

The contribution from Dawn Woodgate at the University of Bath (page 23) shows mobile devices being exploited for several of their unique affordances, specifically their awareness of location and their ability to capture physical data, and for a personalised and contextualised learning experience. This nicely illustrates the ability of mobile learning to be situated and authentic, giving real meaning to learning about science and the environment. The contribution however also showcases the novel, ethical problems of working with mobile devices outside the relative safety of the classroom.

The PI project based at the Open University and described on page 29 by Eileen Scanlon and Mark Gaved shows the capacity of learning with mobile devices to cross contexts, for example from class-room to urban environment. The work described in this contribution was part of a much wider set of pilots, all using netbooks to enhance the capacity of children to act as scientists, formulating methods, gathering evidence and testing hypotheses. Using mobile technologies allows these enquiries to be meaningful and structured whilst still ensuring teachers could organise, intervene and support.

The contribution from Jocelyn Wishart at the University of Bristol (page 36) describes a sustained exploration of the role of mobile devices in teacher training. The account looks at supporting learners, in this case trainee teachers, in substantial professional placements and reinforces the experiences and expectations that mobiles can enhance many aspects of this challenging but vital aspect of much professional and vocational training. There are opportunities for maintaining the communication and cohesion across a dispersed community of learners whilst giving them access to information, facilitating reflection, capturing reflection and working on assessments. As with other examples of learning with mobiles away from the formal institutional setting, the ethical dimensions were significant and ranged from legal and statutory issues to ones of embarrassment, discomfort or concern.

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April 2011

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SMS text messaging for real-time simulations in Higher Education

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Phil Marston and
Alastair Gemmell,
University of Aberdeen

A Flood Disaster simulation which uses SMS text messaging was developed for final year undergraduates studying Applied Geomorphology. The objectives were to help learners apply theoretical ideas from their course to a practical situation and to encourage them to make rapid decisions in an authentic context.

Sector – HE
Subject – Geography
Technology – Learners own mobile phones – SMS text messaging

Activity

The flood disaster simulation was based on a real flooding incident which took place in the town of Vaison la Romaine in South East France in 1992, although a fictional name was used for the town in the activity. Before participating, learners were provided with a briefing pack to familiarise them with the geography of the case study site. During the simulation, learners took on the role of a utilities manager and made decisions about what action to take in the face of unfolding events. The simulation ran over three days, with some messages arriving at times which were inconvenient for learners. It began when an information message, alerting the manager to forecasts for heavy rain, was sent to learners (see Figure 1a on page 14). After a pre-determined time interval another message arrived which required learners to make a decision. The response returned by each learner influenced the information and decision messages which followed. Learners' responses had to be submitted within a specified time period, otherwise a default decision was registered. Over the three day period the scenario gradually unfolded in a way which was personalised for each learner, with distinct end points which reflected their path through the scenario. Figures 1b and 1c (on page 14) illustrate decision and end point messages.

At any time during the activity learners could seek additional information to help them make their decisions. The tutor played the role of a representative from civil defence HQ and pointed them towards further information in response to specific requests. A print out of the decisions made and the end point of the scenario provided material to support reflection by learners, and the assignment task was to produce a reflective log in which the decisions made at each stage of the simulation were justified.

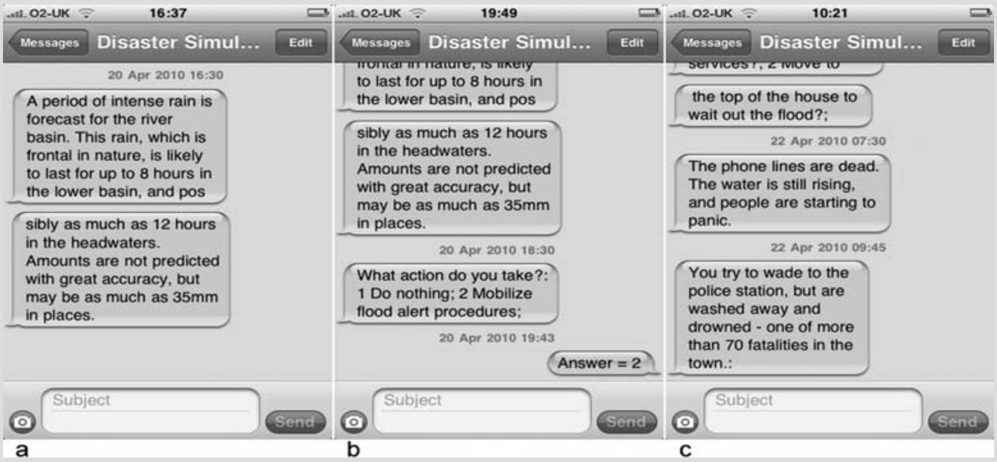

Figure 1: a) opening information message; b) example decision message; c) example end point message

Pedagogy

The simulation provided a learning experience that used an authentic context to permit the application of theoretical knowledge to a practical case, with an assignment designed to promote reflection. SMS was selected for this activity because of the opportunity it provided for anytime, anywhere access to learners. This allowed the activity to take place in real-time, at realistic times, and beyond the normal classroom environment.

Technology

Learners used their own mobile phones – they could participate in the activity as long as they could receive and send text messages. Ethical concerns about accessibility and the potential for learners to incur costs led to the development of a 'back-up' email system which ran alongside the SMS system. Learners could elect to send and receive messages by email and/or SMS. In practice all participants used SMS, and since the majority had unlimited or high volume text messaging facilities, charges, if incurred at all, were minimal. Email was used as a back up by some learners, but not all had access to email from their place of residence, so a mobile phone offered the best opportunity for a real-time activity.

The design of the scenario and input of message text was carried out via a custom built interface developed at the University of Aberdeen. The design and construction of the 'branching decision tree' behind the simulation was not a trivial matter. Even for a simple scenario, such as the Flood Disaster simulation which has five levels of decisions, there are 32 possible outcomes, all unique, and all of which need to be articulated in brief SMS messages. Messages were sent using an automated email-SMS system (from an external service provider) so the tutor did not require a phone for the activity.

In addition to the design of the scenario and population of SMS message database, the tutor had a number of roles: collation of resources, briefing of learners, supporting the simulation and assessment. However, during the three days that the simulation actually ran, there was relatively little time commitment required from the tutor.

Organisation and logistics

At the University of Aberdeen the academic tutor was supported by a learning technologist who set up and maintained the technological infrastructure behind the simulation. This technologist was initially also supported by a programmer who coded the design interface. Learners registered their mobile number using a web interface, with error checking undertaken by the technologist (a process which could be automated).The technologist was also responsible for monitoring and facilitating the activity once in progress. The simulation has on occasions been severely affected by technical issues beyond the tutor or technologist's control. These have included breaks in national mobile services and non-delivery and delay of messages. On one occasion the start of the activity had to be delayed after a mobile network failure. Non-delivery of messages has occurred on occasions and since the order of messages is critical to the simulation, this has the potential to create confusion for learners as their messages may arrive out of sequence resulting in default decisions being recorded on their behalf.

Learners' experiences – acceptance/attitudes

The experiences of learners who undertook the activity in 2008 were reported in Cornelius and Marston (2009). Generally respondents (16 questionnaire respondents and two interviewees) were enthusiastic about the simulation, particularly about the assessment strategy adopted because it was not "just another boring essay". Most respondents looked forward to messages arriving and enjoyed the real-time aspect of the activity – they were unconcerned about receiving messages outside normal 'working' hours. One interviewee commented that 'you feel more involved in the thing because you didn't know when you were going to get the updates…that was fun.'

Evidence has revealed some learners were engaged by the activity, and a degree of emotional involvement occurred. Where successful, participation led to a wider appreciation of the impact of flood prevention initiatives and an acknowledgement of different perspectives. However, not all learners engaged in the same way, and there is evidence that a surface approach (e.g. choosing a pattern of responses) may have been taken by some participants.

Learners suggested that the realism of the scenario would be improved if more information was included in the text messages, or if there were more than two options for action to choose from. These are issues that could be addressed – newer phones and smart phones will accept longer messages, and a more complex decision tree is at least theoretically possible, although it would require substantial design work.

Sustainability and scalability

An important aspect of sustainability is re-use. The model has also been adapted for other case studies, including a contrasting example for a mentoring simulation, in which work-based learners, who will take on the role of mentors for new learners on an adult literacies teaching qualification, are able to gain some experience of a mentoring relationship. Through an unfolding text-based dialogue they make decisions which impact on the development of this relationship. In this implementation formal assessment was not conducted, but opportunities were provided for reflection and discussion following the simulation using online discussion forums. This particular implementation created some additional technical challenges and prompted different learner reactions, which may be attributable to the nature of the learner group and the work-based learning context (see Cornelius and Marston, 2011).

However, the overuse of mobile learning activities such as SMS simulations may impact on learners' experiences. One of the interview respondents cautioned against too much use of mobile phones for learning in general to prevent boredom and a less positive response to the disruption involved. However, the Flood Disaster simulation is scalable to any number of participants. In the model of implementation as described above, a large number of participants would create additional work for the tutor in terms of support and assessment, but no additional technological requirements.

For effective reuse a realistic and authentic scenario which can be represented by a simple branching tree structure, good briefing of learners, the opportunity to trial the approach with learners, implementation with sensitivity to the learners' context (e.g. acceptable mobile phone usage policies and practices), with the provision of opportunities for reflection all appear to be important.

Since the simulation employs learners' own mobile phones and intrudes into their personal time, there are some ethical issues which require consideration. As the activity uses learners' own phones, they need to provide their private numbers to register for the activity. In the Flood Disaster implementation, these numbers were not seen by the tutor, but only handled by the technologist. There is also the potential for participants to incur costs and the issue of intrusion on learners' personal space and time, including, potentially, work time. However, with the undergraduate geographers these issues did not appear to create barriers – indeed many learners enjoyed the real-time element and welcomed the opportunity for "learning to come to them". There were also some issues of accessibility created by the need for learners to turn off phones whilst at work, although they adopted strategies to cope with this, and simply returned to the scenario as soon as possible. These issues might be more pronounced with other groups of learners – and the work-based cohort who undertook the mentoring simulation provide some examples of intrusion becoming 'inappropriate' and the difficulties of access created by work policies and practices.

Recommendations for other practitioners

An SMS simulation is an interactive replication of an authentic scenario, using SMS text messaging in real-time to facilitate the application of theoretical knowledge and rapid decision making in response to an unfolding scenario. The decisions made by learners provide a personalised experience and outcome. The design requires the creation of a 'virtual context' – a persistent, consistent, realistic physical and social scenario where text messaging is an appropriate tool for communication. Briefing and familiarisation are essential steps prior to implementation to ensure that the learner's context is considered and that the disruptive element of the simulation is appreciated. This also allows any technical issues to be addressed in advance. Following implementation opportunities for the articulation of experiences and reflection, both on the product and the process, are important stages to help consolidate learning.

Author details

Sarah Cornelius is Lecturer in the School of Education, University of Aberdeen. Her research interests are in learners' and teachers' experiences of technology enhanced learning and recent projects have explored web conferencing, mobile simulations and online role play in higher education and work-based learning contexts. She has extensive experience of the design, implementation and evaluation of flexible online learning for adults in Higher Education and the private sectors and is also the co-author of a successful textbook on Geographical Information Systems.

Phil Marston is a Learning Technologist and Research Student in the School of Education, University of Aberdeen. He lectures on undergraduate and postgraduate programmes across a range of disciplines, as well as being involved in staff development. His research interests are in the role of play, emotion, storytelling and context in mobile learning, virtual worlds, simulations and game-based learning, particularly in higher education. He has previously worked in the fields of management training, community ICT training and more recently as part of a team of learning technologists supporting a variety of disciplines in higher education.

Alastair Gemmell is a Senior Lecturer in the School GeoSciences at the University of Aberdeen, where he is extensively involved in undergraduate teaching in the field of Physical Geography, especially with respect to Geomorphological theory and its practical applications. His main research interests lie in the fields of glacial and Quaternary geomorphology, where his principle research area is in the refinement of luminescence dating techniques. He also has interests in the development and deployment of new, interactive approaches to teaching aimed primarily at giving students practical experience of management problems in environmental applications of geomorphology.

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Postgraduates, field trips and mobile devices

Nicola Louise Beddall-Hill, Learning Development Centre, City University, London

This research focuses upon the role mobile devices play in learning on field trips (see Beddall-Hill & Raper, 2010; Beddall-Hill, 2010). My studentship is linked to the Semantic Technologies for the Enhancement of Case Based Learning (Ensemble) project, part of the Technology Enhanced Learning (TEL) initiative under the jointly funded (ESRC & EPSRC) Teaching and Learning Research Programme (TLRP).

My background and interest in this area arises from my experiences as a teacher and lecturer in a wide range of educational contexts. Some of my roles involved technology enhanced learning, which led to this research area. This case study arises from work concentrating on theoretical aspects of learning with mobile devices. Weaving these findings with my more practical teaching experience will hopefully provide some guidance in designing to enable learning with TEL in similar settings.

Sector – HE

Subject – Geographical Information Science

Technology – Smartphones, PDAs and GPS

Ethnographic research was undertaken with postgraduate students on MSc in Geographic Information Science (GIS) courses during three residential field trips. Emerging from geosciences and information systems, GIS is linked to the development and marketisation of geographical positioning capabilities (GPS). GIS is used widely for visualising geographical information alongside data such as demographics so it is valuable for decision-making. A typical student is an international, mature male looking for a career change or progression within their current role where GIS knowledge would be advantageous. The focus is upon the practical skills they need to develop alongside the theory; hence field trips are vital to allow real world application to practise those skills.

Pedagogy: field trips and case based learning

The field trip setting is a highly complex semi-formal learning environment. It usually employs collaborative case-based learning strategies often inspired by the kind of projects students might expect to undertake in employment. The materials and guidance to aid their design and analysis are provided. The implicit learning aim is to experience the processes of conducting research or work-related activities in the

Figure 1: Teaching devices: PDA, Smartphone and differential GPS

real world. These trips allowed the observation of small groups of postgraduate students engaged in joint knowledge construction and mediation with the natural world via mobile technologies. Within this setting the tutor, learner, curriculum and device create a complex web of intersecting formal educational, natural and social worlds. This creates a rich picture from which to draw lessons about the use of technology in fluid contexts. Field trips are therefore thought provoking settings for researchers to explore TEL, especially since technology is emerging as a unique and impactful tool with which to explore the natural environment.

Technology

Over the last decade, technological developments have influenced the geosciences, especially in regards to fieldwork. Information technology (IT) is used for a variety of functions before entering, while in and after leaving the field. Its capabilities allow opportunities not previously available. For example, Fletcher *et al.* (2003) report that handheld Global Positioning System (GPS) devices featured largely in fieldwork, as was seen in this case study. However mobile phone use was higher in fieldwork than GPS and their use was also extended to pre and post field course work (Fletcher *et al.*, 2003). This latter finding was mirrored in this research at one of the three settings, suggesting a continued infiltration of personal mobile devices, especially mobile phones, into fieldwork. Maskall and Stokes (2008) believe that using devices enables data collection and analysis *in situ,* enabling feedback to inform changes for further investigation. Stott (2007) also found Personal Digital Assistants (PDAs) valuable for fieldwork enabling data sharing and storage, despite their difficulties with screen visibility in sunlight and their lack of built-in waterproof protection. However as Smartphones become more able to handle data processing and storage, PDAs may become less prevalent. In addition to the mobile technologies described above both of the Universities observed used their Virtual Learning Environments (VLEs) to host preparation material for the fieldwork and used GIS visualization software to conduct the data analysis.

The devices present on the field trips observed included PDAs with GPS, GPS trackers and differential GPS devices (Figure 1). The majority of functions such as GPS track logging, data recording, analysis and visualization via GIS software (run on a Windows Mobile platform) can be run on some Windows Smartphones (Figure 1).
Additionally these Smartphones can access the Internet if needed, provide communication and media capture; no specialist GIS devices perform all these functions. Smartphones are limited by Windows-only GIS software and the greater accuracy of differential GPS devices, although this is likely to change, dispensing with the need for some specialist devices. Fletcher *et al.,* (2003) suggests carefully considering the choice and cost of fieldwork equipment, as well as the time to learn to use it and develop materials suitable for it. With the rapid

development of mobile technology, devices will quickly date; hence the utilisation of students' personal Smartphones may be more efficient. The next section of this case study considers the issues implicit in using teaching and/or personal devices in fieldwork.

Issues to consider

The use of institutional versus personal mobile devices is a contentious debate and this case study does not attempt to fully address such a complex wide-ranging situation. Instead it considers the relative advantages and issues inherent in using different devices from the observations undertaken. Ownership is an emergent theme in this research; three kinds have been observed; 'borrowed', 'partial' and 'personal'. Each has a different influence upon the student's appropriation of the devices for learning. The observations suggest that in settings that enable choice, the learners are favouring their personal devices over teaching devices.

Teaching devices

When using mobile technology in the natural environment, issues surrounding battery life, processing power, visibility, durability and usability become apparent. The choice of device and subsequent limitations will depend on which functions are of most relevance to the task. Using teaching devices allows more control over these decisions but adequate testing and back ups are essential. During trips where the teaching devices were supplied two forms of ownership were demonstrated; 'borrowed' and 'partial'. These differ according to who has responsibility for the care, charging and use of the devices throughout the time on the field trip. Where a device is 'borrowed' the lecturer controls the device including its care, charging, assisting with uploading software/ downloading data; this may be suitable for some learners, especially younger ones. The student has 'partial' ownership of a teaching device when those responsibilities become theirs with guidance where necessary. In this situation students often developed a level of attachment to the devices, preferring one to another and spent time 'playing' with the device to learn its functions.

Using teaching devices means that logistically all the equipment has to travel to the field centre and is ultimately managed by one or two of the lecturers present. Due to the cost of the equipment it may be difficult to replace, repair or upgrade regularly and students need to share devices. However using teaching devices does mean the course is not reliant on students' technology, which may vary widely. Also personal data is unlikely to be encountered on a teaching device, as they are not generally linked to external networks so m-safety concerns are reduced.

Personal devices

Personal mobile technology (Figure 2) has an ever-growing presence within fieldwork due to the data collection and navigational options it now affords. The observations made here suggest that at least in some UK Higher Education environments students are more likely to have technology and mobile devices capable of many of the tasks previously reserved for teaching devices. Harnessing these resources could prove beneficial to all parties. The students could save time learning to use a new device and instead have sole use of a device they have transferable knowledge over, thereby saving time and cost for the lecturer setting up and managing a collection of devices. However, harnessing personal devices is not without distinct drawbacks that need careful consideration and which vary according to the context. Educators need to be aware of the reduced control they have and there may be problems accessing personal devices in regards to sensitive data and m-safety issues. Using personal devices will also largely depend on the institution's and the students' attitudes.

Figure 2: Personal devices: iPhone 3GS & digital camera

Pachler et al. (2010) propose 'a view of school as cultural practices of teaching and learning into which the cultural practices of the use of mobile devices and their applications in everyday life need to be assimilated'. As seen in some fieldwork settings this assimilation has begun to take place and is largely orchestrated by the learners. During the last field trip the lecturer's own Smartphone was used as a teaching device and several of the students used their own Smartphones (in particular iPhones) to capture media and collect GPS track logs alongside the teaching devices. Therefore they appropriated their personal technology for the task, as they preferred and trusted it. The lecturer's Smartphone may have influenced their perceptions of what technology is appropriate and trustworthy, but several students may have used their own devices in similar ways before; using this knowledge they created new practices with their devices. This is illustrated by using the devices to download applications, search related information, and check weather reports. Some used their phones when the GPS trackers where running low on battery. Therefore they appropriated both the teaching and personal devices to suit their learning needs, blurring the boundary between social and learning purposes. This may have been a unique situation; in previous field trips personal devices were mainly used for social communication. However the factors that underpin such decisions may be numerous; in previous settings roaming charges abroad or more limited devices may have inhibited this choice.

Outcomes and guidance

The most important aspects of teaching with mobile technology are preparation and flexibility. Suitable software, hardware, battery options and back up facilities need to be available. Also prior to the trip consider the following: supplying preparation materials (perhaps via a VLE), building in practice with the teaching and/or personal devices leading up to the trip, keeping the projects fairly loosely structured to allow for creativity and flexibility. Finally assessing students' knowledge of the technology to be used informally and formally and the technology they have access to.

However, despite the best preparation things often go awry, hence flexibility becomes key in using a different device, method or no technology at all. Students are likely to encounter similar instances where creativity is needed. Indeed the observations demonstrated how the students moulded functionality of the devices to fit their changing needs. Furthermore it is necessary to accept that technology is developing at a rapid pace, hence impossible to future-proof, and that all devices will have limitations. Therefore integrating the students' devices could prove beneficial where the situation, institution, devices and consent allow. At this point using a blended model of teaching and personal devices might be the most appropriate and beneficial solution. This reduces the shortcomings of the different models of ownership and allows choice for the students in their learning needs and tools. In the near

future this area will continue to evolve but towards which model of ownership (institutional or personal) is currently open to debate.

Project website: www.ensemble.ac.uk/project-team

Author details

I am in my final year of a TLRP TEL studentship at City University, London. It is linked to the Ensemble project, (http://www.ensemble.ac.uk/) which focuses on mobile devices on field trips. Prior to this I taught in a variety of subjects and settings including; A-level Psychology, PE and horse riding both in the UK and abroad. My interest in learning stems from these and my prior studies; PGCE in Post-Compulsory Education, MSc Sports and Exercise Psychology (both Sheffield Hallam University) and BA Hons in Social Sciences at Nottingham Trent University. I hope to continue working, researching and developing practice in the technology-enhanced learning.

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Bringing school science to life: Personalisation, contextualisation and reflection of self-collected data with mobile sensing technologies

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'It is a real wow factor, the fact that it opens within Google Earth, and it is their data, and that is really powerful…' Hilary, science teacher.

What follows is informed by insights from several years' work (which is ongoing, and continuing to develop) with mobile sensor technologies for data collection to support science learning in schools across a range of Key Stages. The activities described below took place at a relatively early stage of our research. Since then however, similar activities have become integrated into the curriculum in a number of schools, including contributing to coursework projects for GCSE and A level examinations.

The work itself initially arose in response to a challenge posed by the 2000 Government White Paper *Excellence and Innovation: A Science and Innovation Policy for the 21st Century,* which outlined concerns about young people's perceived loss of interest in science relatively early in their school careers, typically at the transition between primary and secondary schooling. One result of this is that large numbers drop out of science subjects at the end of the compulsory period, rather than going on to study them at A level and beyond. Science, Technology, Engineering and Mathematics (STEM) subjects are considered vital to the UK's competitiveness, and concerns about the level of STEM skills among the UK workforce and young people entering it remain.

One issue that has been identified as pertinent to this loss of interest is that of a tendency to change from the pupil-centred, hands-on learning activities that characterise primary school science, to the more theoretical approach taken in many secondary schools, to teach the factual information necessary for examination success. We do not dispute the necessity of understanding scientific theory, and would make the point that this is a generalisation; both primary and secondary schools vary in the extent to which they embrace hands-on learning styles, and curriculum innovations such as *How Science Works* have had some impact. The school involved here is a secondary school which is extremely receptive to innovative learning activities; they would have been very unlikely to have agreed to take part in our research had this not been the case.

Our 'challenge' was to show how new technologies can potentially increase pupils' interest and motivation in science, and through hands-on activities, help them engage with aspects of scientific knowledge and scientific theory.

Sector – UK secondary education, Key Stage 3 (11-14 years).

Subject – Science

Technology – PDAs, GPS and data loggers

Pedagogy

Mobile sensing enables groups of learners to collect environmental data in their local area using a simplified version of the equipment used by professional scientists. For example, pupils can collect data on parameters such as light and humidity to help them understand the reasons for variations in plant species occurring in different locations, such as under trees as opposed to open grassland, or to monitor carbon monoxide levels around their school at different times of the day, to help them understand the impact of road traffic. When such data are displayed in compelling ways, children not only gain insights into aspects of the underpinning science (which can of course be built upon in class), but can be encouraged to engage in other learning activities as well, such as discussion, presentation of their findings and report writing. Since these are activities that professional scientists engage in, they can thus gain insights into aspects of the working lives of scientists.

Technology

Broadly, the technology shown in Figure 1, currently comprises a datalogger with internal light, temperature and sound sensors, and the facility to plug in a range of other sensors to collect data on different parameters. Equipment of this type is relatively common in secondary schools, although our experience has shown that it is under-utilised, at least partly because it tends to be perceived to be difficult and time consuming to use. The dataloggers are used in conjunction with handheld Garmin GPS units. Data are collected with both simultaneously, typically as part of a practical outdoor environmental science lesson, or on a field trip, and subsequently downloaded to a PC with bespoke software installed, which creates a .kmz file, effectively tying the environmental data to the specific location in which it was collected, and enabling its visualisation in Google Earth. The technology has undergone a number of iterations over the last five years, and teachers and school pupils have been extensively involved in its development and testing[1].

[1] *The equipment was designed, manufactured and supplied by Science Scope of Bath.*

Figure 1: The sensing kit; Science Scope data logger with an external sensor attached, and a Garmin GPS

Activity

The participating school in this instance is a Hampshire secondary school catering for pupils from 11-16 years of age. It is one of a number of schools with whom we worked during the *PARTICIPATE* Collaborative Research and Development project[2]. We worked with two teachers at the school: Hilary, an experienced science teacher and Matthew, a newly qualified teacher whom she mentored.

Due to the relatively early stage of development of the technology at this stage, alongside the usual time and curriculum constraints, preparation for exams and large number of additional commitments in the school calendar, the activities described below took place as an enrichment activity at the very end of the school year, after the GCSE and other examinations, where additional teacher time was freed up by the early departure of the year 11 pupils.

At the relatively early stage of the project during the host school's involvement, a group of teachers from a number of schools across the UK were invited to attend a teachers' workshop hosted by our BBC partners, whose purpose was to introduce the Participate project and the technology, and suggest some possible activities. Teachers were encouraged to contribute their own ideas for activities and contexts within which they could envisage using the equipment. Those who decided that they would like to take part were offered the loan of equipment and support from within the project.

Hilary decided to use the equipment with large and lively Year 7, 8 and Year 9 classes, and involved Matthew, a newly qualified teacher whom she mentored, and a trainee teacher on teaching practice at the school. It was decided that groups of pupils would be asked to collect data around the school, download it, and carry out an activity to present their data and help them reflect upon it. They were allowed considerable freedom to choose the type of data they wanted to collect, within the constraints of the selection of sensors provided, and could choose to create either a poster or a photostory presentation on the topic to present their findings. These materials, along with data trails created by the pupils were, subject to school and parental consent, uploaded to a secure website[3] to allow project researchers access to the material, and enable limited

[2] *The PARTICIPATE collaborative research and development project ran between 2005 and 2008, and was supported by the Technology Strategy Board and the Engineering and Physical Sciences Research Council. Partners were the universities of Bath and Nottingham, BBC, BT, Microsoft, Science Scope and Blast Theory.*

[3] *This website is at www.participateschools.co.uk. Note that some examples of data trails and pupils' work are available, by consent, on the public page. This includes some international examples.*

Figure 2: Monitoring traffic noise outside the school

sharing of data and classwork across schools. Many of the pupils chose to measure and record sound levels around the school, as it was something different from the usual science topics, and, as considerable variation in sound levels can be found within a school, particularly where building work was taking place as it was here at the time, this choice ensured that the data would be varied and interesting (Figure 2).

Outcomes

As Hilary's quote at the start of this case study indicates, the pupils enjoyed their role in the project, both the activities themselves, and their interactions with the project team. Their input, and that of the teachers, was of considerable value to the iterative development of the software in particular.

- The activities prompted even younger pupils to think critically about both the data and the methods used, and to relate the particular (i.e. their own experiments and observations) to the more general. Year 7 student 'Robert' noted and commented upon the limitations of GPS when a snapshot reading that he took on the school sports field appeared to have been taken from the roof of a school building when visualised in Google Earth™. Pupils of all ages have commented upon the need for repetition of experiments, and have sometimes pulled us up on this when time constraints did not permit it. Typical comments were: *'we've only done this once so our data's not reliable*', or *'but that's rubbish science because you know, we've only done it once, so how do we know that that's really the quietest place'.*

- Our observations have indicated that the activities gave children confidence to examine and evaluate professionally produced data, such as that provided by local councils.

- Even pupils with challenging behaviour were reported to respond enthusiastically to the activities. One Bristol teacher commented that she was amazed that some class members who 'could be disruptive at times' were so knowledgeable about technology. We surmise that one reason for this may be that it allowed them to express their 'non-school' knowledge and link it to classroom activities, which increased their confidence and interest in the classroom topic.

- All self collected data engaged the pupils, even quite bland seeming materials from very early requirements gathering trials. Some studies have suggested that more discussion is provoked by less obviously engaging materials than by more detailed and precise visualisations. Linked to this, in some instances, Google Maps™ visualisations were shown to be more effective in enabling the understanding of a specific concept than the more immediately compelling Google Earth™ ones. For example, in another school, A level students studying the changes in conductivity along the course of a river as part of a field trip reported that a Google Maps™ visualisation made it immediately easy to grasp the concept. A Google Earth™ visualisation would have appeared too 'busy' in this context. Stripping away the unwanted detail made the data much clearer. On the other hand, pupils at a Bath school enjoyed discussing the precise locations of carbon monoxide peaks in familiar locations around the two split sites of their school, shown by the Google Earth™ visualisation shown at Figure 3.

Figure 3: An example data visualisation in Google Earth, to show carbon monoxide levels in a city street.

Recommendations for other practitioners

- Teachers need time to become familiar with new equipment. In this case, both teachers tried it out themselves during half term in advance of introducing it to the children. They then presented it at an in-service training (INSET) session, to familiarise colleagues. Since then, it has featured in Continuing Professional Development (CPD) and INSET programmes in which a number of schools have taken part, including a CPD activity at a local Teacher Training college involving 10 primary schools in Somerset and South Gloucestershire, to which one of the authors contributed. Once it is introduced however, our experience shows that pupils quickly become 'expert' and enjoy helping new groups to use the equipment, and demonstrate and present it during assemblies and parents' evenings.

- It is vital to include ICT departments in CPD and INSET activities, and to gain their cooperation and assistance in respect of installing software and helping with any technical issues that arise. Manufacturers of the products are also a valuable source of information and advice – they want schools to have a good experience of using their products.

- Activities such as those described have been reported to facilitate fulfilment of some of the requirements for Initial Teacher Training and the Continuing Professional Development of qualified teachers, for example in respect of ICT, collaborative working etc.

- Think about the practicalities of using sets of equipment that need to be kept together, as seen here. Numbering or colour coding of sets of equipment is vital. Some schools have reported keeping it in separate boxes or bags which are similarly labelled, for ease of use, to help with the issuing of clear instructions to pupils, avoid confusion when data come in to be downloaded, and to help pupils, teachers and technicians to put it away neatly at the end of the lesson so that it can be quickly and easily accessed next time.

- Mobile Sensing data where location based data are displayed can pose a possible security issue. For example, in some situations children have asked to take the equipment home to collect data during their journey (or in the early stages of the research, when visualisations were less clear, some teachers even suggested this). This is of course fine so long as the data are kept confidential within the school. It is necessary to avoid displaying such data at events open to the public, or uploading to websites, as showing a child's quite precise route between home and school can potentially compromise child safety. For this reason, we would recommend using it in and around the school grounds, or on organised visits or field trips only. If used outside of these contexts, parental involvement is recommended. For example, pupils at a Bristol school decided to collect data on car trips to local places of interest and visits to relatives which were undertaken with their parents at weekends.

- Finally, Mobile Sensing activities can contribute to other areas of the curriculum than science, such as ICT, geography, PE and English. In some schools, cross-curricular projects have been initiated.

Final word

Many schools have now taken part in various Mobile Sensing projects with the CREATE Group at the University of Bath. Ages of pupils involved range from nine to 18 years. The results of new, quantitative research are now supporting our earlier observations that Mobile Sensing enthuses pupils, and increases motivation.

Dawn Woodgate, Danae Stanton Fraser and Susanna Martin are members of the CREATE research group at the University of Bath.

Author details

Dawn Woodgate is a visiting fellow at the Department of Psychology at the University of Bath, and a member of the CREATE research group at the University. She has a first degree in biology, and is a qualified teacher with considerable teaching experience, mainly in the post-16 sector. Subsequently, she returned to study, and completed a Masters in Research (Methods) and an interdisciplinary PhD in psychology and science and technology studies. She has carried out research and consultancy across the fields of psychology and human computer interaction, mainly in the real world contexts of education and healthcare, and has published in a number of domains, including high impact journals.

Personal Inquiry Project: Progress with Open University trials


Eileen Scanlon and Mark Gaved,
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Personal Inquiry (PI) is investigating the use of scripted inquiry learning and mobile technologies in formal and informal science learning settings. Mobile technologies provide new opportunities for teachers and learners to engage interactively with different types of science learning and new models of inquiry learning which make use of these may impact on the experience of the science learner (Scanlon et al., 2005). In this paper we describe trials undertaken in Milton Keynes by The Open University working alongside a local secondary school, Oakgrove School.

Partners: The Open University, University of Nottingham, Sciencescope Limited. Participating Schools: Oakgrove School, Milton Keynes; Hadden Park School, Nottingham.

"Personal Inquiry: Designing for evidence-based inquiry learning across formal and informal settings" is funded by the ESRC/ EPSRC TLRP Technology Enhanced Learning programme.

Sector – UK secondary education, Key Stage 3 (11-14 years).

Subject – Science and Geography curriculum

Technology – Netbooks, GPS, data loggers and digital cameras

Pedagogy

We are interested in how school students can be helped to learn the skills of evidence-based inquiry and how learning can be supported across formal and informal settings. Technology, and mobile technology in particular, offers the possibility of supporting the transitions made by learners across settings. One of our main challenges is to develop support for evidence-based inquiry learning, using a 'scripted personal inquiry learning' approach. Our work has involved seven trials at two schools with over 300 students aged 11-14 who are conducting a range of inquiries in science and geography (Collins et al., 2008; Anastopoulou et al., 2009) supported by a Personal Inquiry toolkit. This consists of a range of scientific data gathering equipment such as sensors and cameras together with a web-based software toolkit that supports students' progress through the different phases of their inquiries.

The toolkit provides 'scripts' that guide the learners through a process of gathering and assessing evidence and conducting experiments. The scripts guide students and teachers through the inquiry process. Each inquiry is supported by an instantiation of a script which specifies how the inquiry is organised and presented. This helps the learners to plan and monitor their work and allows the teacher to orchestrate activities. The script may specify who can progress through a given inquiry, and by what means, for example as a whole class, in groups, or individually, and whether the teacher or the students prompt the availability of the next activity (Mulholland et al. 2009). The availability and content of the activities can be altered as learners progress through the inquiry learning process.

Another key concept is the attempt to build upon young people's own interests for school purposes: we have been exploring what is meant by "personal" inquiries. We want the learners to be responsible for formulating their own questions for investigations, which might be personally relevant to their lives, arguing that these will be more engaging, in line with the strategy document 'Harnessing Technology: Next Generation Learning' (Becta, 2008).

When discussing mobile learning, the topic of informal learning becomes salient as mobile learning often takes place outside traditional educational settings; Scanlon et al. (2005, p4) identify three facets of mobile learning which are particularly significant.

First, that learners are on the move, moving around physically but in other ways too, for example between devices and over time. Secondly a vast amount of learning that takes place outside formal learning situations and thirdly the ubiquitous nature of learning

A particular focus of interest for us in the project therefore is the transitions between formal and informal settings that could be enabled by mobile technology.

We have undertaken seven trials in two schools investigating topics including urban heat islands, microclimates, healthy eating, and the product cycle of foodstuffs. Investigations have mostly been carried out within the curriculum though we have supported one less formal inquiry into sustainability in an after-school club. In this paper we will refer to trials carried out at a school in Buckinghamshire, supported by The Open University.

Software: the PI toolkit

The software application is accessed via a web browser. This was chosen as it is familiar to school students and teachers so little training was required. The structure was devised in collaboration with the school teachers and led the students through the stages of the science inquiry (see Figure 1).

At the beginning of the inquiry, students used the PI toolkit to enter an overarching hypothesis, and in some inquiries were then prompted by the teacher and the software to break this down into constituent key questions. Students then chose from a selection of measures how they would undertake their research (e.g. measuring temperature and wind speed of an

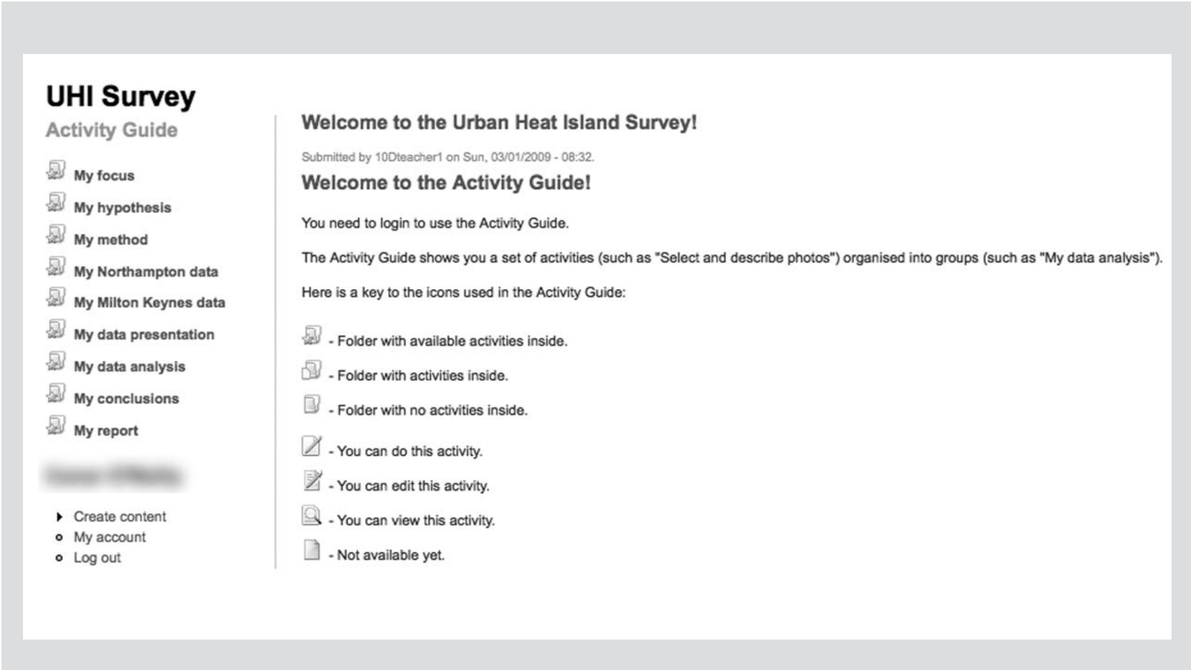


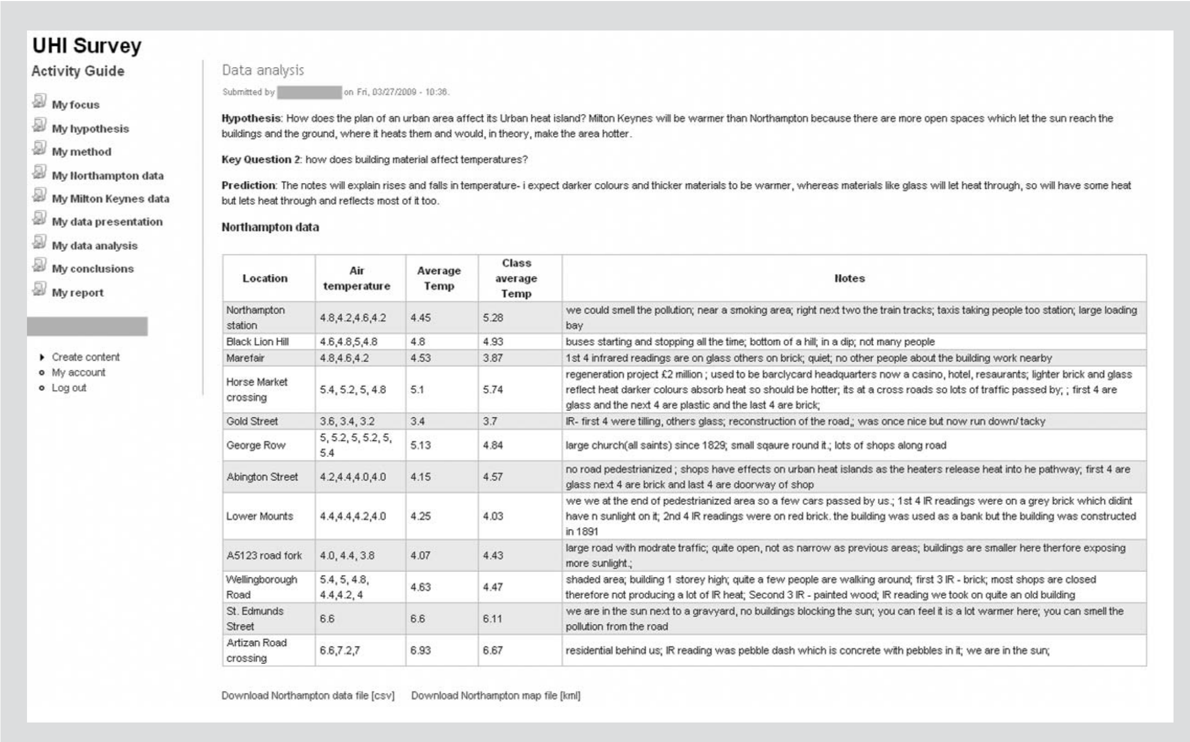
Figure 1: Introductory screen for the software application showing phases of an urban heat island inquiry, student logged in. Note that this version was locally titled the Activity Guide.

environment), and then considered which tools would be most appropriate to choose to collect data to respond to their questions. Students were helped by supporting documents held in the toolkit previously created and uploaded by teachers. These included introductions to the topic, exam board guidelines, and a report writing checklist. Students would then collect data, which could take various forms depending on the investigation, for example collecting environmental data and recording building usage for the urban heat islands investigation, and noting local climatic conditions for the microclimates investigation.

On completion of data collection, students would move to analysing data. From this point on students would work on a range of computers: in school ICT suites, at home on their own computers, or continuing using the netbooks connected either via a school network or a home connection. Data was then analysed using the PI toolkit and other software tools (e.g. spreadsheet and graphing software) and subsets of the complete data explored (see Figure 2). The system would prompt students to match their data against their original predictions and enable a conclusion to be added. To support writing up of reports, students were able to export data in common formats for automatic import into Excel spreadsheets and generation of labelled Google Earth maps. Reports would be completed either within the toolkit or finished by exporting sections to a word processor and completion there.

Hardware

Asus Eee PC netbooks: light, portable, good battery life, wifi connectivity and solid state memory drives. They were found to be ideal for use by students across contexts and for use throughout an



UHI Survey

Activity Guide

- My focus
- My hypothesis
- My method
- My Northampton data
- My Milton Keynes data
- My data presentation
- My data analysis
- My conclusions
- My report

- Create content
- My account
- Log out

Data analysis

Submitted by [redacted] on Fri, 03/27/2009 - 10:36.

Hypothesis: How does the plan of an urban area affect its Urban heat island? Milton Keynes will be warmer than Northampton because there are more open spaces which let the sun reach the buildings and the ground, where it heats them and would, in theory, make the area hotter.

Key Question 2: how does building material affect temperatures?

Prediction: The notes will explain rises and falls in temperature- i expect darker colours and thicker materials to be warmer, whereas materials like glass will let heat through, so will have some heat but lets heat through and reflects most of it too.

Northampton data

Location	Air temperature	Average Temp	Class average Temp	Notes
Northampton station	4.8,4.2,4.6,4.2	4.45	5.28	we could smell the pollution; near a smoking area; right next two the train tracks; taxis taking people too station; large loading bay
Black Lion Hill	4.6,4.8,5,4.8	4.8	4.93	buses starting and stopping all the time; bottom of a hill; in a dip; not many people
Marefair	4.8,4.6,4.2	4.53	3.87	1st 4 infrared readings are on glass others on brick; quiet; no other people about the building work nearby
Horse Market crossing	5.4, 5.2, 5, 4.8	5.1	5.74	regeneration project £2 million ; used to be barclycard headquarters now a casino, hotel, resaurants; lighter brick and glass reflect heat darker colours absorb heat so should be hotter; its at a cross roads so lots of traffic passed by; ; first 4 are glass and the next 4 are plastic and the last 4 are brick;
Gold Street	3.6, 3.4, 3.2	3.4	3.7	IR- first 4 were tilling, others glass; reconstruction of the road,; was once nice but now run down/ tacky
George Row	5, 5.2, 5, 5.2, 5, 5.4	5.13	4.84	large church(all saints) since 1829; small sqaure round it.; lots of shops along road
Abington Street	4.2,4.4,4.0,4.0	4.15	4.57	no road pedestrianized ; shops have effects on urban heat islands as the heaters release heat into he pathway; first 4 are glass next 4 are brick and last 4 are doorway of shop
Lower Mounts	4.4,4.4,4.2,4.0	4.25	4.03	we we at the end of pedestrianized area so a few cars passed by us.; 1st 4 IR readings were on a grey brick which didint have n sunlight on it; 2nd 4 IR readings were on red brick. the building was used as a bank but the building was constructed in 1891
A5123 road fork	4.0, 4.4, 3.8	4.07	4.43	large road with modrate traffic; quite open, not as narrow as previous areas; buildings are smaller here therfore exposing more sunlight.;
Wellingborough Road	5.4, 5, 4.8, 4.4,4.2, 4	4.63	4.47	shaded area; building 1 storey high; quite a few people are walking around; first 3 IR - brick; most shops are closed therefore not producing a lot of IR heat; Second 3 IR - painted wood; IR reading we took on quite an old building
St. Edmunds Street	6.6	6.6	6.11	we are in the sun next to a gravyard, no buildings blocking the sun; you can feel it is a lot warmer here; you can smell the pollution from the road
Artizan Road crossing	6.6,7.2,7	6.93	6.67	residential behind us; IR reading was pebble dash which is concrete with pebbles in it; we are in the sun;

Download Northampton data file [csv]   Download Northampton map file [kml]

Figure 2: Data analysis table view – student comparing selected measures to answer a key question

inquiry. The netbooks run the Linux operating system which, while new to students and teachers, was quickly adopted and had open source versions of familiar tools (e.g. Open Office – an open source equivalent of Microsoft Office). Thus the netbooks could be used not only to access the PI toolkit but also enabled the students to write up reports and undertake other schoolwork activities. An unexpected benefit was that this meant that common Windows viruses were not transferred from students' memory sticks.

ScienceScope data loggers and sensors: designed for school use, providing accurate scientific measurement, including temperature, humidity, wind speed, and infrared irradiance from buildings.

Garmin eTrex GPS receivers: providing locational data that could be typed into the PI toolkit and enabled generation of Google Earth visualisations.

Canon Powershot cameras: enabling collection of rich visual data.

Participants can use any computer with a web browser to connect to a central server running the PI toolkit. Where we could not be sure of a good internet connection (such as fieldwork or when students worked at home), the PI toolkit was loaded onto individual netbooks. Students worked individually or in groups on these netbooks and data was sychronised with the central server afterwards. We have also tested connectivity over 3G phone networks which enables connectivity in a wider range of fieldwork environments.

Organisation and logistics

Trials involved one to four teachers and 12 to 150 students, with one or two researchers evaluating usage, and two or three researchers providing technical support. Researchers first worked with teachers to agree on a topic within the curriculum

that the teachers would like to deliver in collaboration with the project, and a participatory design process would be undertaken to generate a new version of the software toolkit that would support learners and structure their progress through their inquiries.

The software toolkit was then loaded onto the central server, and possibly individual netbooks depending on the nature of the inquiry. Setting up and managing class sets of up to 30 netbooks and ten or more data collection equipment sets was time consuming, with an initial set-up, synchronisation of data once collected, and ongoing technical support. Guidance for connecting netbooks to home internet connections proved the greatest challenge though the majority of students achieved this in each trial. Students taking equipment home had to be reminded to charge batteries, and we found it was a wise precaution to bring in spare batteries to each session. The equipment worked well throughout the trials. The solid state memory and rugged construction of the Asus netbooks combined with their small size and light weight meant that they could be incorporated into the students' routines and carried around regularly in school bags without suffering damage.

Where internet connectivity was required, for example where it was important that students could upload data immediately onto a central server to see each others' work in progress, or access resources from the internet, site surveys were undertaken by technical researchers. In some cases data collection routes were modified to take into account connectivity, or additional network provision set up. An alternative approach was for copies of the software to be run on each netbook given to each student (or group of students) and all netbooks to be synchronised after data collection, though this was more time consuming.

Acceptance and attitudes

Students accepted the hardware and toolkit and experienced few difficulties with its use. Most of the devices were familiar to students (e.g. digital camera, netbooks) and the unfamiliar devices (e.g. data loggers and sensors) were quickly assimilated into their working practices. The key challenge we faced was achieving home internet connectivity on the netbooks.

Netbooks themselves were immediately accepted by the students with individuals finding and experimenting with the default software tools provided with the devices and appropriating the netbooks for their own purposes. When loaned, the students also used them for completing other schoolwork and for entertainment. Students identified the netbooks as 'theirs', personalising them in various ways such as changing the background colours and replacing the web browser home page with their personal favourites, such as YouTube or social network sites. Interviews with students indicated that family members were also keen to try out the netbooks.

Teachers' reactions were positive; they felt that students were engaged well with the inquiries and were able to undertake richer than usual investigations with the technologies. The data loggers and sensors allowed for more accurate and extensive exploration of the environment and the toolkit loaded onto the netbooks structured students' progression through the inquiries across contexts (at school, in the field, and at home). One teacher noted that the students worked better using the netbooks in her classroom than when using the school's computers in the ICT suites.

Students were engaged by the personal aspects of the inquiries and enjoyed being able to make choices and consider topics relevant to their own lives. Some students' attitudes to their environment were changed as a result of their participation in the inquiries and interviews indicated that parents had taken an interest in the work the students were undertaking and, in at least one case, changed their own buying habits in response to their child's research into food packaging.

Sustainability and scalability

The PI software application has now moved towards a stable release version and we have set up a website so anybody can download and try the software themselves (www.nquire.org.uk). This provides documentation, online support, and examples of inquiries. Our current objective is the further development of web based authoring tools that will allow teachers to generate new inquiries or modify existing inquiries for their classes with little outside input, so would anticipate that future trials would be set up and run by teachers themselves rather than requiring researcher support. We are currently demonstrating the software at conferences and developing an early adopter community that will be able to offer support through the website and forums to further users. The software is based on open source, standard tools that were chosen for their existing large and active user communities. Hardware was deliberately chosen as familiar, off-the-shelf equipment that is found in UK secondary schools, so support could be managed in future by school IT technicians.

This paper has been written on behalf of the OU/PI team: Canan Blake, Trevor Collins, Ann Jones, Lucinda Kerawalla, Karen Littleton, Paul Mulholland.

Project website: http://www.pi-project.ac.uk

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He has explored adoption of networked technologies, particularly within mobile, fieldwork, and informal contexts. His research has considered their application and usage both in community and educational settings. Mark has participated in local networking initiatives as a practitioner and described this phenomenon in his PhD research.

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Handheld mobile devices in initial teacher training

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Over a five year period starting in October 2004 handheld personal digital assistants (PDAs) were made available to groups of volunteer student teachers selected at opportunity in order to identify where potential learning and teaching support opportunities were borne out in practice. Several of these projects were funded by the UK Teacher Development Agency. In each case the students were participant action researchers acting on their teaching and learning by means of the PDA and then reflecting on and amending their practice (Wadsworth, 1998).

Sector – University based Initial Teacher Education (PGCE)

Subject – Science (three groups), Modern Foreign Languages (one group)

Technology – PDAs

Technology
Though the devices used ranged over the years, all were advertised as PDAs (running Office functions such as word processing and spreadsheets as well as a browser), incorporated a camera (both images and video) and could be used to communicate via voice, SMS (text), email and Bluetooth. In years following the first year all PDAs purchased had inbuilt wi-fi.

Activity
In the first year, 14 student teachers following the one-year science PGCE (postgraduate teacher training programme) were given either a Windows Pocket PC or a Palm OS-based handheld and trained in its use. Cell phone data packages including access to web pages and email were provided by Vodafone as it had proved reliable in the project area in a pilot test though students would be expected to pay for any voice calls they made. During the training students were shown how the PDAs have potential to support them in:

- collaborating via the VLE (Blackboard) discussion groups and email;
- accessing course documentation (on PDA or via Blackboard or via synchronisation [synching] with a PC);
- just-in-time acquisition of knowledge from the web;
- acquisition of science information from e-books, data tables and encyclopaedias;
- organising commitments, lesson plans and timetables;
- recording and analysing laboratory results;
- recording pupil attendance and grades;
- capturing images eg. of experiments and demonstrations for redisplay to reinforce pupil knowledge;
- maintaining a reflective web log (blog) that could allow them to record lesson evaluations and other reflections on their teaching.

This pattern was repeated in the following year but with only the six students placed at different times during the year in a single school and also loaning PDAs with wi-fi running Windows Mobile 5 to the 13 science teachers in the school. Practising teacher engagement was sought to remove constraints reported by the first group of students who felt that having the PDA drew unwarranted attention to them and to involve school based mentors in the e-learning community linked to the initial teacher training course more. In the third year, the remaining wi-fi enabled PDAs were loaned to a group of seven modern foreign language (MFL) student teachers to gain information from a contrasting context. In the fourth year an updated model of PDA was acquired with similar functionality but incorporating a camera with better resolution and running Windows Mobile 6 which meant that students' data was no longer lost if they completely drained the device's battery. These were used by eight volunteer PGCE science students who were also given access to PebblePad ePortfolio software in order to investigate potential use of PDAs in capturing information including images to be used to evidence their progress against the Qualified Teacher Status (QTS) Standards. These standards, written by the UK's Teacher Development Agency, are competence based and describe the performance expected of a newly qualified teacher.

Except in the final year students reported back on their experiences of PDA use at key points in the PGCE year via questionnaire at half term breaks and at the end of their school based teaching practice placements and via a face to face interview at the end of their course. Up to three focus groups were also arranged at opportunity each year to collect and share experiences on PDA use. In the final year, students were given a freer rein with the devices and were asked only to commit to a final end of course interview.

Pedagogy

The devices were offered to the student teachers for evaluation as to their potential to support them in both teaching and learning activities. This student centred approach was supported through researcher led focus groups and a moderated discussion group for the participants on the course virtual learning environment (Blackboard).

It was noted that many of the successful uses the PDAs were put to by the student teachers supported a constructivist philosophy of learning. For example, making notes on teaching observations in school in separate files (see example in Figure 1) and later, through a process linked to further research and reflection, reconstructing those notes into a written essay in response to a course set task demonstrating their learning.

Figure 1: PGCE student's PDA showing notes made on a lesson observation

Other examples involved using images and video captured of science experiments (example shown in Figure 2) or of one-off events such as demonstrations or role-plays (in both science and MFL) and used to scaffold the pupils being taught in revising and constructing their own understanding of the subject matter being taught.

Figure 2: PGCE Student's PDA showing a photo recording results of an osmosis experiment

In the final two years the PDA project focused on use for assessment rather than teaching with the student teachers trialling PebblePDA, an ePortfolio client from PebblePad, to support completion of their profiles of evidence collected for assessment against the national Qualified Teacher Status (QTS) standards. Here, as exemplified in Figure 3, the student teachers who used Pebblepad Profile were also heavily reliant on the use of the inbuilt camera to capture images of activities and written comments.

Figure 3: Photo submitted by teacher trainee as part of evidence for QTS Standard Q30 'identify opportunities for learners to learn in out-of-school contexts'

Organisational and logistical issues

The PDAs were distributed at the start of each academic year to PGCE students volunteering to be part of the study and who had a home PC they could synchronise with it on a first come, first served basis. Support for data and text costs was offered only in the first two years and was the main organisational issue. Participants signed an acceptable use policy and agreed to refund any voice calls made. In the end, the PDAs were only used for calls on a couple of occasions though one teacher accidentally ran up a bill of tens of pounds checking the cricket scores whilst on holiday. Over the five years there were only two incidents where replacement was needed, one a screen broken by storing the PDA in a bag next to a pencil and the other, a faulty battery.

Acceptance and attitudes

Acceptance was a common issue in these explorations in schools where more often than not pupil use of mobile phones is banned. In the second study where every member of a science department was allocated a PDA there were fewer reports of the devices drawing unwarranted attention but still only small numbers of enthusiasts continued to use the devices. One of whom reported 'I will be at a great loss if you reclaim the PDA from me. I personally find it very useful for collecting data, class marks, making notes during lessons, doing PGCE student observations, sharing files with colleagues and many others.'

As well as reporting discomfort over the issue of using devices banned to pupils the trainees raised concerns over capturing images of children. Even in the final study set up to investigate opportunities for capturing multimedia evidence of their progress for assessment by their tutor, and where such image capture had been cleared with their schools, they were concerned as to how taking photos would be perceived and few took photos of activities, mainly of outside classroom events. It appears that strong socio-cultural pressures militate against the use of mobile devices to support teaching and learning in schools. Hartnell-Young and Heym (2008) suggest that moving the focus of schools' acceptable use policies from the devices themselves to the activities they are used for would be a useful step forward in engendering a more open climate to enable teachers and pupils to explore the potential of mobile phones to support learning.

Sustainability and scalability

In order to afford sustainable, scalable mobile learning for teacher trainees the aforementioned open climate needs to be established and it is recommended that trainees are taught how to use their own mobile phones to support teaching and learning. Loaning devices tends to be problematic; technology changes so often that the loan devices are often perceived as out of date and more importantly, trainees tended to rely on their own phone with its calendar and contacts databases. Carrying two devices was perceived to be cumbersome.

Ethical issues

As described earlier the student teachers' concerns over the use of camera to evidence their progress impacted upon their use of the PDA. They did not feel comfortable doing this even in the school that had a blanket 'pupils may be videoed or photographed to develop teaching within the school' policy.

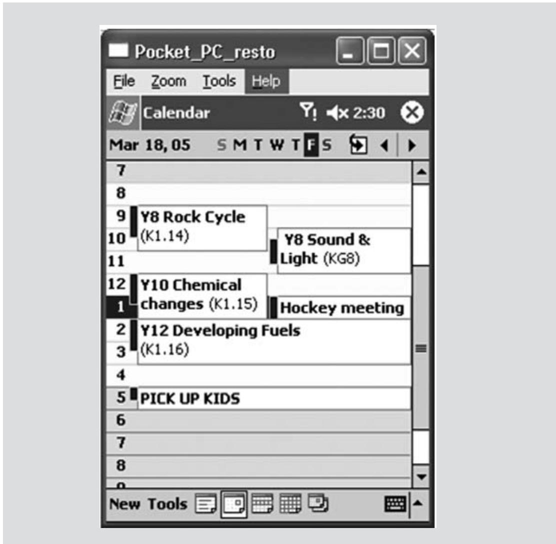

Figure 4: PGCE student's PDA showing their timetable

Outcomes

Whilst a few enthusiasts used the PDA widely there were really only three functions on the PDA that maintained their popularity with the teachers and teacher trainees throughout the series of investigations. The calendar (shown in Figure 4) was popular with one student teacher going so far as to report that "it organises my life". The camera was used at opportunity to record personal and work events by the science teachers and trainees in order to enhance their teaching with images from local contexts and for both their own interest and assessment records. It was common too for students to make notes with either Word™ or the Notes function. The effectiveness of this latter activity is reinforced by this student's report, "During teaching practice I have found myself constantly bombarded with new and noteworthy information (e.g. scientific facts, ideas for teaching approaches, school procedures, evidence for QTS standards etc.). The PDA has allowed me to keep meaningful notes of this information, and structure the information (i.e. file) in a way that allows me to access it easily."

Lastly, accessing email when a desktop computer was unavailable was also popular. However, the students (MFL students in particular) noted that there was nearly always another device available (e.g. laptop, digital camera or audio recorder) that served the purpose better.

Author details

Dr Jocelyn Wishart is a senior university lecturer in Science Education. She became involved in Mobile Learning through her interest in using handheld devices to support teacher trainees on placement in schools. She has run several small scale mobile learning projects funded by the Graduate School of Education, University of Bristol and the Teacher Development Agency.

Her interests lie primarily in the psychology of mobile learning and in the corresponding pedagogy of using handheld devices for teaching. She has also published on ethical considerations involved in teaching and learning via mobile devices.

She is Secretary of the International Association of Mobile Learning. Convenor of the IAS Workshop Series 'Adding a Mobile Dimension to Teaching and Learning'. Moderator of the Teaching with Handhelds discussion group at www.handheldlearning.co.uk

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What next?

We come now to looking at the future and the trends in mobile learning. We can explore these in three different and interlocking ways: firstly, looking at trends in mobile learning deployment and implementation; secondly, looking at the likely fate and future of the mobile learning community itself and thirdly, looking at the impact of universal mobility and connectedness on ideas of teaching and learning.

Looking first at mobile learning deployment and implementation, over the last five years several different changes have become apparent, not always clearly or consistently. Organisations and institutions, often unaware of earlier progress, achievements and expectations, have adopted and adapted mobile devices for learning. Meanwhile, there is an increasing fragmentation as researchers, policy-makers, practitioners and corporates diverge and respond to their own pressures and interests. This means that mobile learning is increasingly less coherent as a body of ideas and experiences and at the same time is becoming more accepted as it merges with mainstream e-learning.

Mobile learning pilots and trials in public institutions such as those described here are not often scaled up or sustained. This is often and most obviously because pilots and trials are conducted with provided devices (it is more organisationally convenient and more empirically controllable). Whatever their positive findings, sustaining them is predicated on the finance for continued provision of devices. Understandably but hesitantly, attention is shifting to mobile learning based around learners' own devices. This however raises concerns about lack of standards, stability and uniformity, and about equity and control within the classroom and the institution.

There is however a more fundamental change, a rather obvious change, one that we have so far only hinted at. Until recently, people could only access communities, colleagues, information, images, ideas and interpretations on computers based in their community or college or perhaps in their homes, computers perhaps they shared and were less likely to own or control. Now they can do all these things on mobile devices that they choose, own, value and control. These devices allow them, not only to store, transmit, discuss and consume ideas, information and images, but also to generate and produce them, specific to each individual and community and to their own contexts. Mobile devices have the potential to affect many aspects of the processes by which knowledge, that is, ideas, images and information and their interpretation are produced, stored, distributed, delivered, discussed and consumed. They are now part of a system that allows everyone to generate and transmit content, not just passively store and consume it, making mobile devices an integral part of the Web2.0 ideology that takes people from being merely the Web's audience to its creators. They are however not just static writers for the Web. Their devices are exploiting the capacity to capture or retrieve information that is context-aware and location-specific. Furthermore, social network technologies have now migrated from desktop computers to mobile devices and are supplementing technologies that are 'native' to mobile devices, systems such as Twitter or other micro-blogging systems that connect communities on the move. Multi-user virtual worlds such as Second Life will take on a mobile dimension soon. These changes will further interweave physical and virtual communities and spaces, and interweave real and digital identities. They facilitate the creation and support of discursive communities able to collaborate whilst moving.

Finally, we present two resources garnered from the experiences of the practitioners described here to support those interested in developing mobile learning for themselves. These include a mobile learning practitioner's checklist and a list of recommended sources for further reading.

Mobile learning practitioner's checklist

As a result of our work with mobile devices in educational contexts described in the preceding case studies, we recommend the following nine areas as essential for detailed consideration before engaging in any mobile learning initiative. The list has been divided into three sections relevant to the technical, pedagogic and institutional arenas. For, while we can expect the commercial sector to continue to push for improved technical performance and enhanced functionality wherever there seems to be a business case, in the pedagogic and institutional arenas social practices and expectations will exert continued and complex pressures on the educational process.
At one level these together these inform individual practice within the classroom and lecture theatre but at another level, they argue for a strategic and systemic approach responding to the wider technical and social environment.

Common technical issues:

1. Connectivity - buy a pilot model and try it out in the situations it will be used in.
2. Battery life - spare chargers will be needed for the foreseeable future.
3. Camera resolution – go for the best that can be afforded.
4. Replacement – have spare devices to hand in case of damage.

Institutional concerns:

5. Partnership – the need to work with the institution(s) where the research or teaching initiative is to take place well beforehand to thrash out issues such as bans on mobile phones, wi-fi access permissions, consent to use and ownership of images taken during the research.
6. Ownership of devices - whether to use students' own phones or a 'class set' wholly or partially financed by the institution.
7. Contingency – there will be a need to make time for unforeseen events so that they can be discussed with students and colleagues in the institutions being researched.

Pedagogical advice:

8. Learning opportunities - identify key 'starter' opportunities for students to focus on that are relevant to subject being taught.
9. Constructivist approach - build learning opportunities across and between authentic contexts and the classroom.
10. Student autonomy – the need to work with students to enable them to choose the best ways of using their personal devices to support their learning.

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